

values, and (b), the mean variability, i. e., the mean difference between successive absolute values of the variable.

(a) Our formulæ are exact in both the very different cases where all values are equally probable and where they follow the law of Gauss, as well as in still different cases. Hence, it can not be doubted that they possess a very great degree of generality, and no matter what law which the quantities occurring in meteorological applications might follow, the application of these formulæ would not lead us into serious error; as a matter of fact, such quantities usually follow the law of Gauss quite closely.

(b) The successive values of the mathematical variable are independent of one another, and the mean variability is $\sqrt{2}$ times the mean departure; but for the meteorological elements, particularly for a series of successive daily values, the values are not independent, and the mean variability is usually somewhat less than the above quantity.¹ Hence we should impose on the free mathematical variable the supplementary condition that it have the same mean variability as has the element being considered; unfortunately, one encounters here a mathematical difficulty (also met with in the theory of an imperfect gas) which has not yet been surmounted.

If we arbitrarily fixed the mean variability it would amount to admitting that the probability of the occurrence of a value is a function of the preceding value, which is exactly contrary to the fundamental assumptions upon which the theory of probability rests, and according to which all our formulæ have been derived.

However, the mean variability does not play such an important rôle as it would at first sight seem to; and some simple considerations show that the introduction of a condition reducing the mean variability somewhat would not modify the indications of our formulæ.

¹ Ch. Goutereau, *Sur la variabilité de la température*, *Annuaire de la Société météorologique de France*, 1906, p. 122.

WATERSPOUTS ON THE SOUTHERN CALIFORNIA COAST.

"Visitors at the beaches (Port San Luis, Avila, Pismo, and Oceano) Sunday afternoon about 5 o'clock had the opportunity of observing," says the San Luis Obispo Tribune, "a most unusual phenomenon, that of an immense waterspout traveling at a high rate of speed toward the beach. The spout was shaped like a funnel, and is said to have been about 2,000 feet high, extending as high as the clouds and spreading out into a fine mist. The spout was first visible from Avila and Pismo when it was about 4 or 5 miles distant from the shore, and from that time traveled rapidly until it broke on the beach between Shell Beach and the old Oilport refinery.

"Fishermen who landed at Avila later in the evening stated that they had seen three spouts at one time, two of which were traveling in the direction of the Pecho and one toward Shell Beach. The largest of the spouts was one of those going toward Pecho, and probably covered about 5 acres in area, according to the fishermen."

In describing these waterspouts the San Francisco Call says:

The phenomenon was followed by a tremendous downpour of rain. Fishermen at sea north of the port viewed the three spouts simultaneously. As they approached the shore the two larger ones mounted the headlands, but the third was diverted. It swept around the buoy and proceeded across the bay at a speed estimated to be in excess of 40 miles an hour.

Water within a diameter of from 150 to 200 yards was violently agitated and appeared to be siphoned upward to a mass of clouds some 2,000 feet above. As the spout approached the shore persons near state that there was a tremendous roar. The funnel apparently detached itself from the water and was drawn gradually up into the mass of overhanging, rapidly moving, cumulo-nimbus clouds. Violent gusts of wind followed the appearance of the spouts and continued for several hours.

According to J. E. Hissong, United States weather observer here, the spouts were due to the overrunning of surface air by a layer of colder air as weather control passed from an area of low to an area of high pressure.

The spouts are the first to appear on this coast within the memory of the oldest inhabitant.

INFLUENCE OF THE WIND ON THE MOVEMENTS OF INSECTS.

By WILLIS EDWIN HURD.

[Weather Bureau, Washington, Jan. 6, 1920.]

The weather perhaps has more to do with the control of insect life than all other factors combined, and the significance of this meteorological aspect is varied. Cold, heat, rain, hail, humidity, drought, sunshine, electricity, and wind are factors. Temperature, rain, and wind movement are of utmost economic importance. Sudden cold and rain in early summer may more or less completely destroy the incubating or newly hatched members of what would otherwise prove to be a vast swarm of destructive crop eaters. Drought may retard or destroy numbers of insects in their metamorphoses. Frosts at the moment of appearance of the imago may wreak untold disaster to the tender brood. And prevailing winds may so accelerate or retard the direction of movement of many injurious species at the time of their seasonal advance as to cause or avert great economic disasters.

Thus the winds may upon occasions become the paramount issue of life or death for the little fliers of our fields and orchards. When we see butterflies and other large-winged, small-bodied insects fluttering hither and yon, buffeted about in the air on a windy day, the impression is strong that any extended flight of such creatures must conform with the direction of the wind.

And yet the facts do not always bear out such a conclusion, since in reality the unsteady butterfly is much more capable of forcing itself against the air current than is the heavy locust or the more projectile-like beetle.

The dispersion of insects by means of winds is a matter of constantly increasing agricultural importance. It interests the farmer inasmuch as it may affect his crops; and as it affects the agricultural staples, so does it vitally interest all of us, who need to be fed and clothed. The question was formerly more discussed by the student of geographical zoology, as it affected his plan regarding the spread of a type of life from region to region within coasts or across the seas. The South American locust, for instance, is believed in some scientific circles to be descended from the survivors of an African swarm of identical genus which, following more or less passively in the steady currents of the northeast trades, succeeded in crossing the Atlantic Ocean.

The flights, or migrations, may be largely voluntary, though a good percentage are quite the opposite. In nearly all cases the winds play an important part, and most insects are likely to follow the direction of the air currents, although some are inclined to quarter the

wind or orient themselves against it in flight—sometimes, it seems, out of pure perversity. This orientation, or apparent anemotropic instinct, however, is frequently only the effort of the insect to keep itself on the wing whether poising or in flight while the wind is blowing. Many flies and midges turn to face every passing breeze, poising themselves with wings edged to the wind, and if it becomes too strong, falling to the ground.

The involuntary flights are those in which the insects are picked up bodily and carried from local haunts by the winds, as in the case of buffalo gnats, scales, gipsy moth larvæ, and mosquitoes, or the insects while migrating may be blown from their course by the strong winds of passing storms. Indeed, on some of the tropical islands, nature seems to have stepped in with a special means of protecting some of her tinier creatures. (1) She has gradually dwarfed or eliminated the wings of certain insects, and hence they are unable to fly too high and thus risk being caught in powerful winds and blown to sea.

So air movements of gale force are always a determining factor in the flights of all insects, and certain types may be swept by hurricanes from one island to another, or to a mainland where they had not previously appeared. After the southwest gales of August 26, 1901, numbers of the "blue page" moth of Trinidad were found to have been blown to the Barbados, a distance of 160 miles, and some to Dominica, still more remote. (2) Harmful insects may also be introduced, as has frequently happened in our Southern States, through the agency of the tropical storm. The Argentine pampero at its burst often carries swarms of insects along with it. Sometimes great numbers of calosoma beetles, or, in particular, the light blue dragonflies which inhabit the pampas, are found in advance of the westerly wind in La Plata and elsewhere, instinctively seeking to escape the tempest, and when caught by it are tumbled in downlike confusion by the 70 or 80 mile gale.

But while some insects are thus caught up involuntarily, others of a more helpless type instinctively place themselves in the pathway of the air current. Various insects, notably aphids, are then known to crawl to the tops of plants just before a thunderstorm, and when the first onrush of the wind occurs, drop into it and are carried to new areas, for the purpose of mating.

The sense of smell is highly specialized, hence every breeze from a neighboring food supply is sufficient to cause a flight of winged stragglers against the wind toward the agreeable scent. The plum curculio, for instance, flies to its food supply, the neighboring plum tree, against the breeze. In like manner the presence of a female moth is communicated to the male during the mating season. Many experiments along this line have been conducted. The female moth has been confined in a cage during a breezy period and of the number of male insects observed fluttering about the captive by far the greater proportion of them came to her against the wind.

In connection with the colonization instinct and the influence of the wind upon it the home-returning instinct is so pronounced that the insects will fly against head winds to gratify it. Indeed, it seems probable that the scent of the home colony may be brought to them. The veteran naturalist, Fabre, cites an instance of his own observation (3) in the case of some identified mason bees which he carried from the home swarm to a place between two and three miles distant. Upon their release so stiff a wind was blowing from the direction of the

hive that the bees could not fly aloft where they might have seen the country, but were compelled to fly low. Yet, in 40 minutes, two of the released bees had returned home laden with pollen, and 15 or 20 uninjured insects had returned by the following morning.

The flights of insects may sometimes extend over hundreds of miles, and in this way the faunal zones of many, notably locusts or so-called grasshoppers, and some bugs and beetles, have been widely extended. Immense swarms of locusts, especially, have been seen far from land over the Atlantic Ocean, floating swiftly with the northeast trade winds, and on various occasions they have been known to alight upon the sails or decks of vessels. A recent instance of this nature was reported to the Weather Bureau by Capt. B. Morthensen of the Norwegian bark *Robert Scrafton*. On the 7th of October, 1916, when in latitude 20° 57' N., longitude 39° 28' W., or about 1,200 nautical miles from the African coast, this vessel met with numerous specimens of the genus *Schistocerca* flying on board in a steady northeasterly wind. (4)

Nearly all naturalists and many travelers have had occasion to comment upon the power of the locust and it is unquestionably the most common example of the migratory insects. Cowan relates many a grewsome tale of the locust hordes. (5) He tells us that about the year 872 A. D., according to Wanley's Wonders, a swarm that darkened the sun visited France with the south winds from Africa. They ate all the green vegetation and were finally blown into the sea, whence they were washed ashore in great windrows and there decayed. It was estimated that one-third of the population of France died from the resulting famine and plague.

In 1649 a swarm of locusts was carried by the northeast trades from the Barbary coast to the island of Teneriffe. (6) During the passage the insects rested at night in a great heap on the surface of the water, where many drowned, but in the morning the survivors rose in a mass which glittered in the sun, and on the second day alighted upon Teneriffe. There they were fought unavailingly for two months by 7,000 or 8,000 soldiers, after which the priests tried to drive them away through penances. But in spite of all efforts directed toward its abatement the plague lasted for four months.

In the days before the practical extermination of the Rocky Mountain locust (*Schistocerca americana*) our own country was often terribly beset by this multitudinous pest. In 1855, for instance, it devastated the region around Great Salt Lake, (7) devouring all the growing crops and the prairie grass. A high wind swept the place at the end of the summer, blowing myriads of the insects into the lake, whence they were afterwards washed ashore. When Mr. Jules Remy, the traveler, arrived he saw dead locusts piled a foot high along the beach. The ensuing famine was held by the Mormons to be a "proof of the truth of their religion, because it had happened as among the Israelites, in the seventh year after their settlement in the country."

In 1878, the United States Entomological Commission published a report upon the migrations of the locusts of North America. It was there shown that Montana was a great breeding place for the *Schistocerca*, and that from this territory they descended in vast swarms to the south-eastward as far as Missouri, taking all possible advantage of the comparatively infrequent northwesterly winds that blew on fair days, for the prevailing wind over much of the stretch of country along the route during the summer

season is from the southeast. On a day with favorable winds the locusts were known to fly over the prairie for a distance of 200 to 300 miles.

These creatures in common with some other insects that fly to considerable distances, are furnished by nature with large air sacs which are capable of great dilation, especially when the body cavity is empty of food. The breathing pores are also large, and the locusts may thus become fully inflated with air so that the least possible exertion is necessary to maintain themselves for hours at a time at the swarming height, especially during dry, sunny weather. On very humid days a portion of the dilatable power is lost, and the ease of flight is thus diminished.

Nearly all locusts evidently prefer to fly with the wind, since thus a flight of many hours' duration is accompanied by an inappreciable loss of energy. Then, too, they are not fashioned to fly readily against the wind. The swarms, by instinct, migrate in the direction followed by their ancestors. But before taking a general flight, if the air is calm, numbers of the insects, actuated by the same instinct, are often observed to rise evidently to determine the direction of the upper currents; if favorable to help them along their way, the migration begins, but if unfavorable, they await a more opportune morning.⁽⁸⁾

It has often been observed that locusts are high fliers, and they have been reported at elevations of 13,000 to 15,000 feet. At Bismarck, N. Dak., they have been noted above the cumulus clouds, and Byers tells of two swarms, one above the other, that were seen going in opposite directions with differing air currents.⁽⁹⁾ A change of wind, it is said, will often unbalance the insects to such a degree that they will fall helplessly to the ground before they can recover their equilibrium.

But not all insects content themselves with passivity in the wind. Strange to say, it is the butterfly that has most frequently been observed flying against the wind, although it too does not disdain the friendly current. Yet, as has previously been observed, it is far more capable of making headway against a fairly strong breeze than is the apparently more powerful-winged beetle, or the locust. However, it is the method of presentation of the wing surfaces to the wind that seems to give superiority to the butterfly in this respect. This is particularly true of the *Pierids*, *Danaids*, and *Nymphalids*, which pay as little attention to the wind direction as possible during the fever of the migration flight. With coleopterous insects the condition is different, and in commenting upon the South American beetles, the naturalist Bates says: "It is an admitted fact, I believe, that the steering power of beetles is not great, whilst the horny elytra act as vanes, putting the insect at the mercy of strong winds."

In the history of butterfly migrations—and this insect is sometimes observed flying in vast clouds which reach to a great height—it is found that certain species, notably the *Pierids* of Ceylon,⁽¹⁰⁾ seem invariably to fly directly against or quartering to the monsoon, some moving northward in the fall with the approach of the northeast monsoon, and others, according to some observers, moving southward in the spring when the winds of the southwest monsoon are becoming prevalent. Over Colombo incalculable numbers of white butterflies have been seen fluttering against the stiff northerly winds, and surprised witnesses have claimed that the stronger the air current the swifter is the snowy flight.¹

In September, 1872, Marott observed at sea near Java a column of *Pyrameis cardui* fluttering boldly against the wind, impelled by their strange instinct which seeks to over-come all obstacles. They were constantly buffeted about and beaten back into the water, where they lay dead in such numbers that the sea appeared covered with bright leaves.

Swarms of butterflies have also been met with in our own country, and their movements have been tabulated with reference to the wind. On the 23d of September, 1886, at 7 a. m., Dr. Ellzey (12) saw at West River, Md., "the whole heavens swarming with butterflies." The lower insects were flying about 100 feet from the ground and the upper ones beyond the limit of vision. They were proceeding at the rate of 20 miles an hour against a stiff northeast wind.²

Butterflies have been seen in the North Atlantic 500 miles or more from land, and are frequently carried on shipboard in hurricanes. According to Lucas (13), while in 25° S. latitude and 1,000 miles from the coast of Brazil, he saw several species of butterflies and moths carried in light wind and rain squalls from the westward.

Many forms of insects migrate for some cause or other, but these journeys are usually taken along the path of least resistance. Over the English Channel it is not so unusual as it might seem to discover a swarm of mixed insects, winged ants, syrphus flies, sawflies, and ladybirds floating on the breeze. In White's "Natural History of Selborne," page 366, one reads an account of a shower of aphids that fell in the village on the afternoon of August, 1785, while the wind was in the east from the direction of the Kentish hop district, where the hop aphids were numerous. Similarly, dense swarms of ladybirds, or ladybugs, have come with the wind from the hop fields, where their larvæ have previously fed upon the aphids.

Valley winds, and other rising currents of air, are also determining factors. Thus Lewis relates that, while sitting on the rim of a volcanic crater in Yezo, in July, 1880, he saw beetles carried in an ascending current from the forest below, whence they were precipitated upon the heated lava. The rising air, striking full upon the expanded wings of the insects, was sufficient to carry them upward beyond their power to resist. Similarly, large numbers of ladybirds, flying for food in the elevations of Utah, California, and other Western States, are sometimes caught in the mountain winds and hurled above the snow line to their death.

A few years ago Dr. E. Everling, of Halle, Germany, tried to interest aeronauts in making observations of insects that might be found several thousands of feet in the air. (14) The doctor himself, during a balloon voyage, had found at a considerable height one butterfly which he believed had been carried aloft by a strong vertical current, since it is unnatural for such insects to rise to great heights voluntarily, unless they are forced upward by reason of being the upper members of deep swarms that extend far aloft. In all probability they may sometimes be carried to considerable elevations in thunderstorms, or they may be caught in the fairly strong convection currents which are common even to several thousand feet elevation on warm summer days over land surfaces. These currents often have an upward velocity of 5 miles or more an hour.

The economic distribution of insects, however, is the vitally important portion of the subject to all peoples; and as has developed, of the several controls, the wind is

¹ Some of the observations of butterflies "flying against the wind" may be due to a return current aloft—perhaps the occurrence was during a sea breeze.—C. F. B.

² The usual, southerly, overrunning wind may not have been far up.—C. F. B.

by no means the least considerable. Entomologists agree as to its value among the dispersion factors, as a prime means in spreading insects at the time when they are most susceptible to being carried. This means generally when the insect is in wing, but it is also sometimes true even of the caterpillar stage of existence, and is well known as a dominant factor in the movements of certain other minute insects that can be carried by even light air currents, and which, being able neither to crawl nor fly at will from place to place by reason of their physical limitations, are dependent upon some exterior method of transportation.

This dispersion, however, is not always advantageous to the insect nor injurious to the farmer. A cold wind-storm with driving rain may almost completely destroy a thriving colony of young bugs or flies en route, or a fortuitous wind may blow it away from its natural food supply, instead of toward it, and thus cause it to starve perhaps because of sheer inability to use the plenty in its new domain. Frail insects, like the Hessian fly and the wheat midge, are especially liable to destruction in flight, although they depend upon the wind prevailing at the time when migration must take place to conduct them to the proper food supply.

Most crop-eating insects of the South are migrants and dependent upon the meteorological conditions existing at the time of their appearance. Thus it is seen that the generally prevailing southerly winds of this region in spring spread the flies, weevils, aphids, scales, and plant lice to the northward, whence it sometimes happens that they go too far and are caught unprepared for the vigorous climatic conditions which may assail and destroy them in a single night. The more northern farmer, too, may well rejoice if the hated depredator at the beginning of its peregrinations is caught by a northerly wind, as sometimes occurs, and prevented at the outset from making any further migratory attempt for that season. Webster (15) hinted broadly at the possibilities of conditions of this sort when he said that the prevailing southerly winds during the breeding season in spring spread the "green bug" from Texas northward. If strong north winds prevailed at this time the winged females would be driven southward, and the problem north of the Red River rendered simpler.

One of the most destructive pests of the South is the common Mexican cotton-boll weevil, which entered extreme southern Texas in 1892. Thence annually the insect spread northward and eastward until in 1917, according to the leaflets of Hunter and Pierce of the Bureau of Entomology, 488,240 square miles of the 609,540 square miles comprising the extent of the cotton belt were infested. Two of the greatest fully defined spreads of the weevil were in 1915 and 1916, largely due to the sweeping winds accompanying the hurricane of August, 1915. This storm entered Texas from the Gulf, carrying the insect westward into 29,400 square miles that had previously been free from it in the State; then in the storm's eastward progress over the already infested area of Mississippi and Alabama, scattered the pest for the first time into Georgia. Over a considerable forward portion of this Georgia area, the result of the 1915 invasion was practically unknown until the following year, when the new broods appeared. In 1919 a further immense territory of the cotton belt was invaded, and for the first time the weevil appeared in central Tennessee and southeastern North Carolina. The reason for the extraordinary spread has not yet been determined, although the generally prevailing southerly to southwesterly winds over much of this region during

July and August may have been a considerable factor. Then, too, the weevils were very numerous, owing to the preceding mild winter.

Last season the forces of the Department of Agriculture were closely watching for the possible reappearance of a still more formidable pest—the pink bollworm—members of which had been swept in cotton debris from Mexico into Trinity Bay, Texas, by the 1915 hurricane. (16) But fortunately the insect was not found, so the menace is for the present removed.

But, apart from what we might term the sudden or catastrophic spread of an injurious insect, we have plenty of cumulative evidence of common wind dispersion. If we watch the history of the distribution of the various scale insects, including the pernicious San Jose scale of the fruit orchards, we find that the most frequent winds determine the direction of the spread. Over most of the Middle West and the Rocky Mountain section, the prevailing direction during the period of insect activity is from the southwest, and in these winds, especially during times when their velocity is increased, the scales are picked up like tiny seeds and carried to the eastward, where they may be deposited upon a heretofore uninfested host. The spread is also more rapid up a gully than down a hill, (17) which indicates the considerable ascensional force of the daytime and valley winds. Various experiments have been made to determine the value and extent of this spread. Sheets of tanglefoot have been placed at varying distances and heights from infested fruit orchards, and scales have been found deposited thereon at distances of several hundred feet from the trees.

Similar experiments have been conducted in parts of New England in connection with the spread of the gipsy moth in the prevailing southwesterly winds during the hatching and early larva periods. The author of a bulletin on the subject states that "the wind is almost wholly responsible for the general spread of this insect in New England," (18) and further shows that the larvae, which are covered with specialized long hairs and spin certain buoyant silken webs, are carried sometimes to great distances. In the marshes near Lynn, Mass., newly hatched worms were caught in a west wind having a velocity varying from 7 to 19 miles an hour, and some deposited on a wind catch 1,833 feet distant. At various times the caterpillars have been carried by the wind from the New Hampshire shore to the Isles of Shoals, 6 miles distant. Curiously enough, in the case of this insect the female moth is unable to use her wings for flight, hence the importance of such dispersion through the medium of the caterpillar.

But in the history of the wind distribution of certain insects man and the lower animals have not escaped physically from the incursions of various types, particularly those of the order *Diptera*, through the same meteorological control, for gnats and mosquitoes have carried discomfort, disease, and death on the otherwise comforting breezes.

The buffalo gnat of the southern swamps and bayous is sometimes swept miles from its habitat. It is a blood-thirsty creature and its visits in considerable numbers on the winds have occasioned a great amount of mortality to various animals. In the days while the street cars in Memphis (19) were still drawn by mules, occasions have been known during the season of development of the gnat in the St. Francis bottoms on the opposite bank of the Mississippi River that a strong west wind would bring clouds of the dangerous insects into the city. At such times so great were their numbers and voracity that

they were known to stop the street cars by killing the mules in their tracks.

Like the gnat, the mosquito, usually speaking, is not in the habit of wandering of its own accord far afield, and experiments conducted by the Public Health Service near Augusta, Ga. (20), on marked malaria carriers, found that the maximum natural flight from congested areas was one mile, and from less abundant communities not over a half mile, though occasionally the coast mosquitoes, including the New Jersey brand, are borne inland on the wind (21) 20 miles or more from their breeding marshes in a single night. On various barren keys off the coast of Florida mosquitoes have suddenly appeared when the wind is right to bear them from the breeding mainland. But with a change of direction the insects quickly vanish. The Carnegie Institution has made some studies bearing upon this phase of the question (22). A former WEATHER BUREAU observer, Dr. George Paterson, says that while at Sand Key he occasionally observed a swarm of mosquitoes humming about near the ground, brought in by a wind from the neighboring mangrove swamps and mainland breeding grounds. At such times it was necessary to take refuge in the top of the lighthouse, 110 feet from the ground, and thus beyond the altitude of flight of the pests, to escape them.

In the history of the malarial mosquito little is said about the actual spread of the disease through the agency of the wind, but Ealand narrates one notable example (23), stating that while malaria is not a city disease, conditions may thrust it upon a city, as in the case of Washington, D. C. To the south of Washington at one time lay a marshy area, the Potomac Flats, in which great numbers of the anopheles bred and flourished. With the prevailing summer-night breezes from the south the denizens of the marshes, whose voluntary flights would never have taken them so far, found themselves carried lightly along during their active hours to a rich feeding ground among human beings, where they could satisfy their appetites unchecked. Thus Washington became a city of malaria, and continued as such until the reclamation of the Flats.

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EFFECT OF A FLORIDA FREEZE ON INSECTS.¹

The disastrous Florida freeze of February 2-4, 1917, which killed or practically defoliated the citrus trees in Putnam, Volusia, and Marion Counties, and parts of Lake and Orange Counties, and heavily damaged trees in other sections of the State, was of considerable importance in "reducing the numbers of injurious pests which infested the trees." In the section where temperatures as low as 15° or 20° F. occurred the freeze or the falling and drying of the leaves nearly exterminated the rust mite and varieties of white fly and scale insects. Few adult specimens of the various species survived except on fired or otherwise protected groves or individual trees. Of the red scale it is believed that perhaps not more than 1 in 100,000 remained alive. The almost complete extermination of this species by the freeze and its reproduction to billions in six months is a most remarkable biological fact. In some instances there was no need of the usual early spraying yet, singularly enough, in most cases the normal number of insects appeared in the following summer or fall. So, as a rule, the setback in insect life, however great even over the area of maximum freeze, was only temporary.—W. E. H.

ANIMAL WEATHER PROPHETS.

[Reprinted from *Scientific American*, New York, Mar. 20, 1920, p. 324.]

"Mere superstition," so the weather authorities say, are many of the long-distance weather predictions based on the conduct of animals. No one, so far as we know, has compiled a record of these so-called omens, but their number is multiple. They are based on a belief that animals are able to tell months in advance, for example, the character of the coming winter. If hunters bring a story to the effect that squirrels have made heavy stores of nuts, it is taken to mean that a severe winter impends. If early caught fur-bearing animals have a heavy, thick coat, that is another sign of a severe winter, or a thin coat, the contrary. If bird migrations are delayed after the usual date of the southward flight, a sign is seen of an open winter. Numerous other beliefs based on fancied ability of animals to foresee weather conditions months ahead, and base their preparations on them, have wide currency. Sometimes signs are taken from the vegetable world, as for example, the past fall in the Middle West. Corn husks, it was related, were much heavier than usual—that meant a hard winter.

The reasoning, such as it is, in many of these weather signs, is apparent on the surface. In the case of others it isn't, as with the most famous and well-known of them all—the groundhog sign. If Mister Woodchuck on Candlemas day—February 2—sees his shadow, issuing experimentally from his den, then "winter will have another flight." Otherwise an early spring impends.

Observation over a part of a single lifetime would demonstrate most of these weather signs as unreliable, yet they cling on, especially in country districts. It is possible that they do so, in part, because they shadow into animal signs of a different class which really are dependable. From the conduct of animals, accurate weather predictions can, within certain limits, be made.

This dependable class of animal weather signs is uniformly short distance as to prophecy—no longer than the daily newspaper weather forecast. They occur because

¹ "The Effects of the Freeze of Feb. 2-4, 1917, on the Insect Pests and Mites on Citrus," by W. W. Yothers, Bureau of Entomology, Orlando, Fla. From *The Florida Buglist*, vol. 1, No. 3, Dec. 21, 1917.